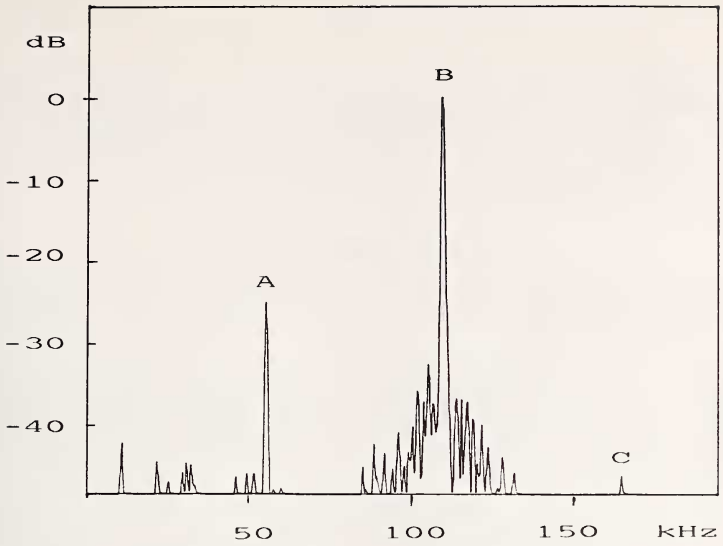

Fig. 3. FFT-analysis (Fast Fourier Transform, with Hanning weighting) of a CF-part of a pulse showing a maximum sound pressure at 110 kHz for the second harmonic (B), a weaker peak at 55 kHz (−42 dB relative to B) for the fundamental (A) and a third harmonic at 165 kHz (C) (−46 dB relative to B)

discussed e.g. by Sales and Pye (1974, p. 58) and was described for *Pteronotus parnellii* (Suga 1984).

The lesser horseshoe bats were also using other sounds at times, especially when they were circling around the entrance to their roosts or when they were hanging on twigs or small rocky outcrops. In the latter cases the differences mainly consisted of a varied pulse length and repetition rate. My material is still insufficient to give a detailed description of these sound types.

At one occasion I made an observation suggesting that *Rh. hipposideros* can use the 'flycatcher' behaviour described in tropical *Rhinolophus* species (Schnitzler et al. 1985). A lesser horseshoe bat was observed hanging on a small rocky outcrop. After a while it flew away out in the vegetation. I could hear it fly around but lost contact with it very soon. Coming back to the rock a couple of minutes later, I found the bat hanging on exactly the same place again.

Discussion

Bats with CF-components can separate their frequencies individually and thus might avoid interference (Miller and Degn 1981). They are likely to return to their optimal frequencies when hunting alone. Rhinolophid bats can compensate for doppler shifts to keep echo within a narrow band of best auditory frequencies (Schnitzler and Henson 1979; Sales and Pye 1974).

The ultrasonic sounds used by *Rhinolophus hipposideros* in a summer nursery colony (indoors) were studied in England by Kay and Pickvance (1963). They reported that the female bats had a very small range of frequencies, only 3 kHz, from 110–114 kHz. The small range of frequencies seems surprising since about 60 bats were present. K.-G. Heller (pers. com.) recorded hand-held specimens of five *Rhinolophus*-species where *Rh.*

hipposideros of various origin (Southern Germany and Greece) ranged from 105 to 111 kHz.

When comparing the same bat species from a number of geographically different localities it could not be excluded that there is a greater variation in frequency. Therefore it is noteworthy that even my data on *Rh. hipposideros* from a number of colonies in different parts of Spain did not show much variation. This suggests that the auditory system is sharply tuned to the optimal frequency of the species and that the local populations do not show much acoustic variation.

Acknowledgements

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Zusammenfassung

Ortungslaute von fliegenden Kleinen Hufeisennasen, Rhinolophus hipposideros (Bechstein, 1800) (Rhinolophidae, Chiroptera), in Jagdbiotopen

Laute der fliegenden Kleinen Hufeisennasen wurden mit Tonbandgerät in natürlichen Jagdbiotopen in vielen Lokalitäten in Spanien aufgenommen. Der gewöhnlichste Ortungslaut besteht aus einem etwa 50 Millisekunden langen konstantfrequenten Signal mit einem kurzen frequenzmodulierten Anfangs- und Endteil. Der Konstantfrequenzteil hat die stärkste Komponente mit etwa 110 kHz. Das ist der erste Oberton, während der Grundton bei 55 kHz schwächer ist. Die Laute werden etwa zehnmal pro Sekunde ausgesendet. Die Variation an Ortungslauten zwischen Individuen und Populationen war sehr klein, wahrscheinlich ein Ausdruck für einen sehr engen reizbaren Frequenzbereich im Gehörorgan. Eine Observation deutet an, daß Kleine Hufeisennasen die Jagdtechnik der Fliegenschnäpper benutzen.

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Structure of *Lepus nigricollis* hair from various body regions with Scanning Electron Microscopy

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Abstract

Scanning Electron Microscopic (SEM) studies were made on the morphology of hair samples of the head, neck, dorsal body, ventral body, fore-limb, hind-limb and tail regions of the Indian hare, *Lepus nigricollis*. The hairs of various body regions tend to differ in colour and size. The type and pattern of arrangement of cuticular scales of these hairs also vary considerably from region to region. Scanning electron microscopic studies on the morphology of hairs of various body regions of any mammalian species form a useful tool in the identification of prey species by the analyses of faecal matter of predators, and for evidences for the presence of various species of animals in any forest habitat.

Introduction

'Trichology', the scientific study of hairs has specific relevance in the dietary investigation of carnivores and field survey of mammals (Day 1966; Dreyer 1966; Ryder 1973; Perrin and Campbell 1979; Keogh 1983; Buys and Keogh 1984). Data obtained from recent wildlife surveys in various forests of Kerala make it possible to determine that there is a need for the identification of various mammalian hairs, especially those of the prey species, which facilitate the conclusive identification of the presence of various mammal hairs in the faeces of predators (Vijayan et al. 1979; Balakrishnan 1984; Balakrishnan and Easa 1986). The faecal matter of most of the wild predators have considerable quanta of hair and occasionally have undigested bones. The hairs of larger prey such as the sambar deer, *Cervus unicolor* and the spotted deer, *Axis axis;* can be comparatively easily identified in the droppings of larger carnivores such as the tiger, *Panthera tigris* and the wild dog, *Cuon alpinus*. However, a thorough identification of hairs commonly seen in the droppings of smaller predators such as the jungle cat, *Felis chaus;* the Asiatic jackal, *Canis aureus* and the Indian fox, *Vulpes bengalensis,* are difficult. Hence, an attempt has been made to identify hairs of a number of mammalian species from various forests of Kerala with the aid of Scanning Electron Microscopy. The present report incorporates the data on the fine structure of hairs of various body regions of the Indian hare, *Lepus nigricollis*.

Material and methods

Lepus nigricollis (Cuvier) of both sexes (four males and four females) were trapped from forest habitats in Wynad and Trivandrum, Kerala and hair samples were plucked carefully from their head, neck, dorsal body, ventral body, fore-limb, hind-limb and tail regions using a fine forceps. These samples were kept in hexane or in 70 % alcohol for 1–72 h for cleaning and were dehydrated in ascending grades of alcohol. Hair samples were cross sectioned at about the middle portion using a fine stainless steel knife. A few hairs were also sectioned longitudinally.

The samples were then mounted on studs, dried using a vacuum dryer and gold coated in a Type JEE 4B Vacuum Evaporator at high vacuum. These samples were scanned under a JOEL JEM 100C/ JOEL JSM 35 Scanning Electron Microscope at an accelerating voltage of 10 kV and studied at magnifications ranging from X300 to X10,000. For comparison, exposures from middle portions of the samples were used.

Results

Observations on the morphology of hair collected from different regions did not reveal any marked sexual dimorphism and hence the data from male and female hares were combined. The table shows the data on size and pattern of colouration of hair samples of various body regions. In general, these hairs have a length of 10–25 mm depending on the body site of its

Table. **Showing the size and colour pattern of hairs of various body regions of the Indian hare, *Lepus nigricollis***

Body region	Hair size, mm*		Colour pattern of hair			
	Minimum	Maximum	Proximal	Middle	Distal	Distal tip
Head	10	12	White-brown	Black	Cream	Black
Neck	18	22	Cream	Grey	Cream	Black
Dorsal body	18	25	White	Black	Cream	Black
Ventral body	12	18	White	White	White	White
Fore-limb	10	12	White	White	Cream	Cream
Hind-limb	15	20	White	Grey	Cream	Black
Tail	16	20	White	Black	Cream	Black

* Data represent a minimum of 30 samples from each region

origin. The differential colour pattern also helps to identify hairs of one region from those of the other. The hairs of ventral body regions are particularly white and smooth, whereas those of other regions have bands of two to four colours such as white, black, cream and grey. The type and pattern of arrangements of cuticular scales of hairs of different body regions observed with the SEM revealed the following:

Head and neck: The cuticular scales of the hairs of head and neck of the hare are flattened, conical-shaped and are tightly packed. There are a number of ridges and grooves on the surface of neck hairs in the longitudinal plane as a result of the pattern of arrangement of the scales (Fig. 1). The pattern of arrangement of the scales could easily be used to distinguish head hair from body regions, but neck hair and fore-limb hair could not be distinguished by scale patterns.

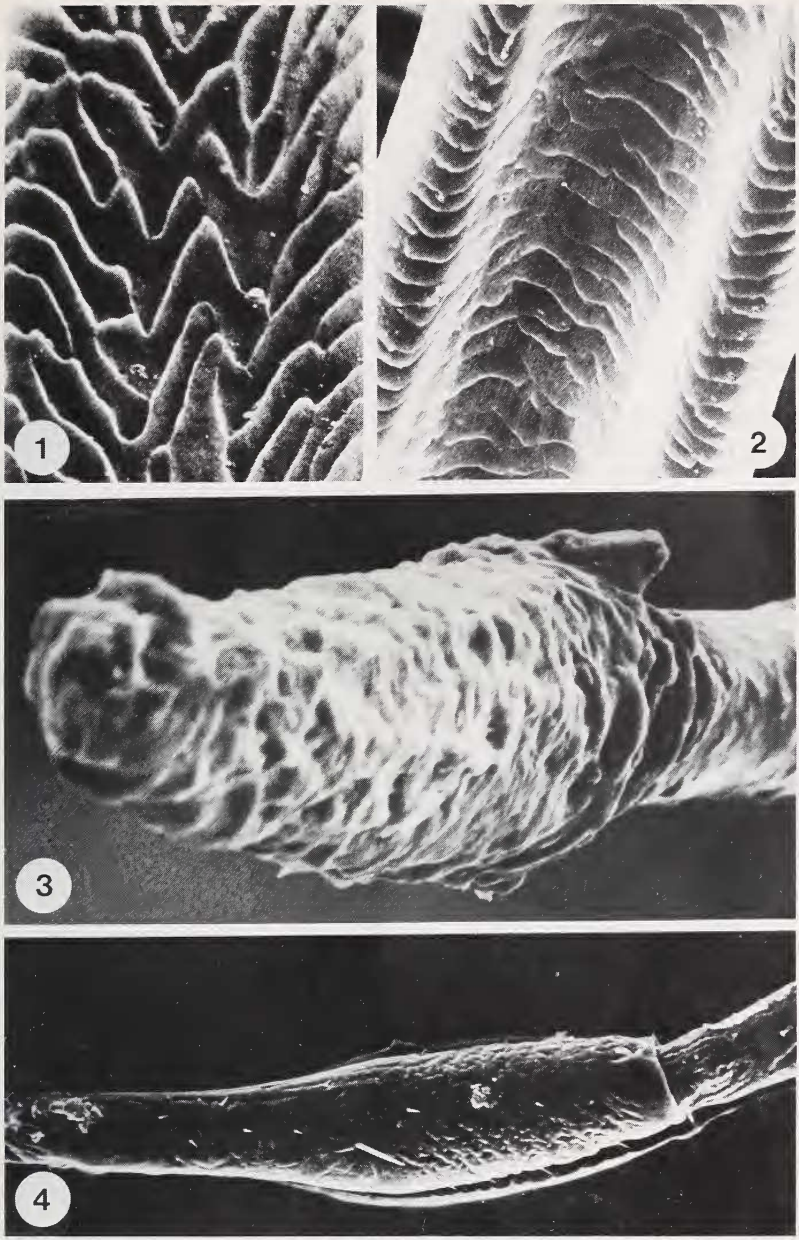
Dorsal body: The cuticular scales of dorsal body hair are flattened and are thickly packed (Fig. 2). Roots of these hairs are thick showing the typical patterns of roots of hare hairs (Fig. 3).

Ventral body: The scales of ventral body hair are elongated in shape and are tightly packed. Elongated grooves on the cuticular surface are also seen as in the case of neck hairs. These hairs are deep-rooted. However, the root is thin (Fig. 4) when compared to the other hair roots. The medulla of these hairs is divided into two columns by the mid-medullary growth of cortical tissues (Fig. 5).

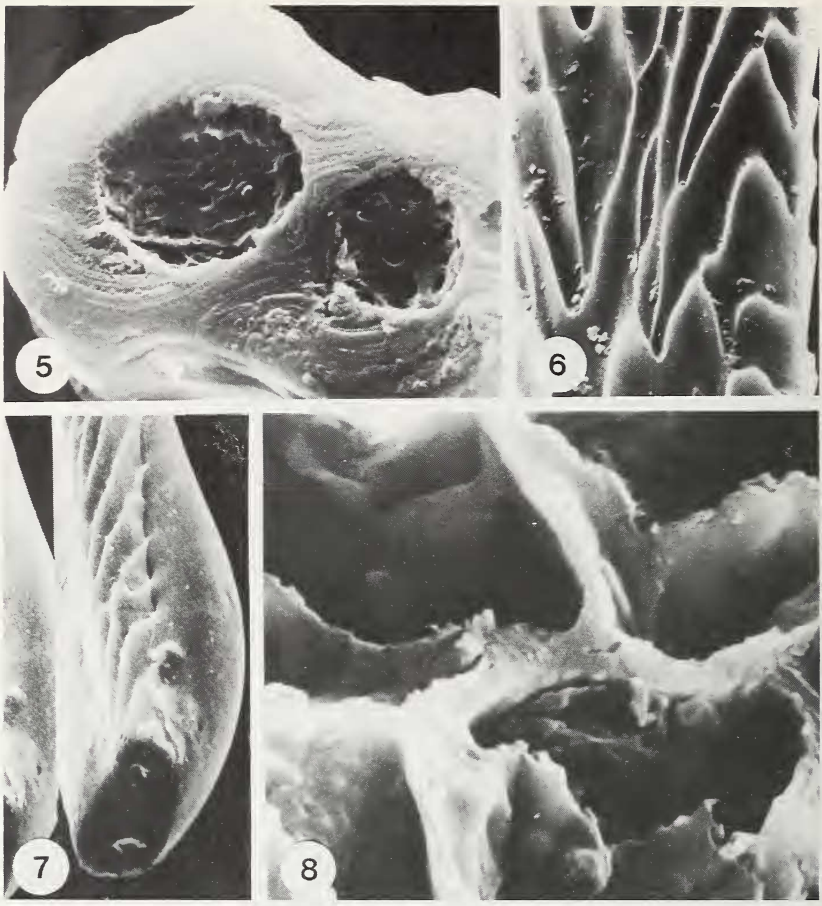
Fore-limb: The scales of the hair of fore-limbs are flattened and elongated, and the distal ends are conical-shaped (Fig. 6). These hairs are not deep-rooted. The proximal portions of them are more or less oval in shape. Cuticular scales are also seen on the surface of these roots (Fig. 7). Well developed medullary cells of these hairs are shown in Fig. 8.

Hind-limb: The scales of the hair of hind-limbs are flattened and thickly packed along the entire length (Fig. 9). The cortex is thin and the medulla is extended with larger cells (Fig. 10).

Tail: The cuticular scales of the hair of the tail are flattened and are similar to scales of hair of the dorsal body region. These scales are also tightly packed in a uniform pattern (Fig. 11).



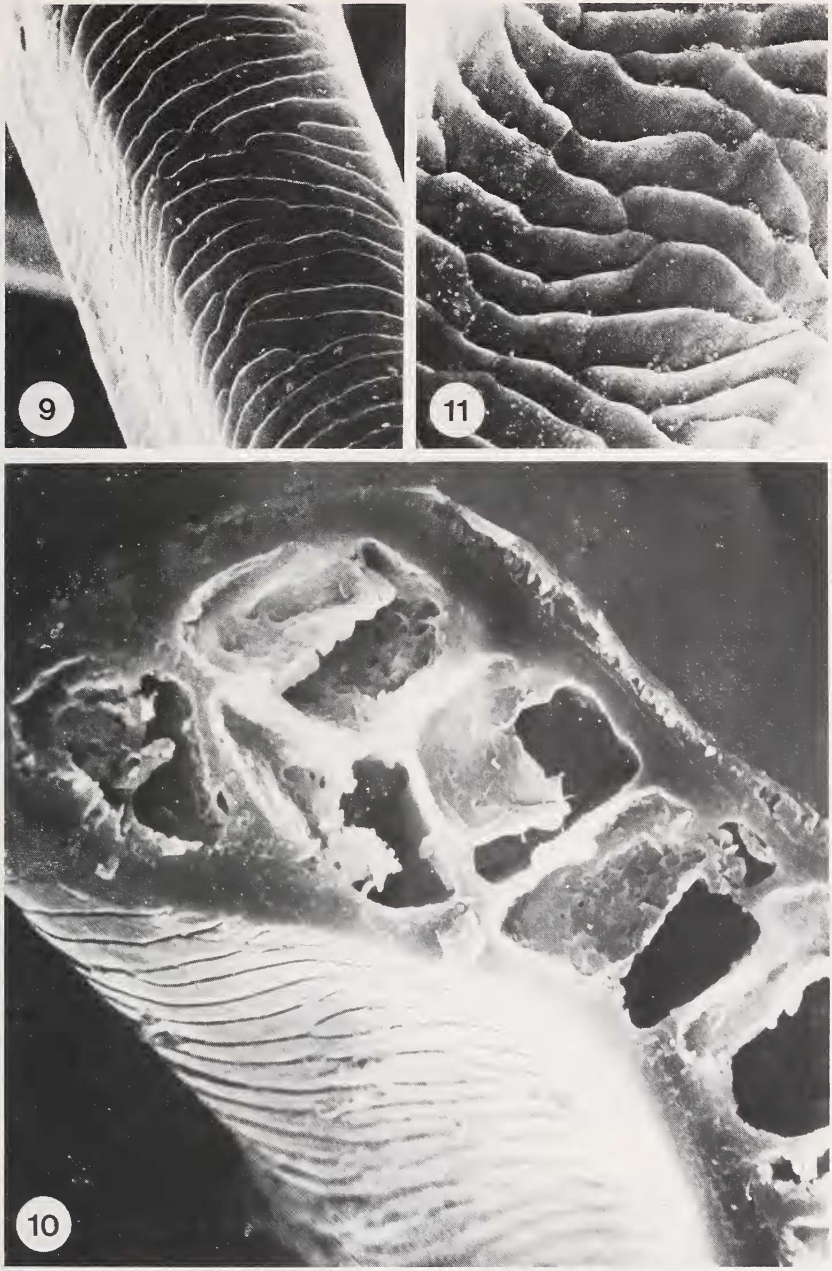
Figs. 1–4. 1: The flattened, elongated and conical shaped cuticular scales of the head and neck hair. (×1,370); *2:* Dorsal body hair showing the tightly packed pattern of arrangement of cuticular scales. (×1,370); *3:* The typical structure of root of hairs of head and dorsal body. (×910); *4:* The morphology of a root of ventral body hair. (Note the difference in the size and shape of roots of dorsal body hairs). (×1,830)



Figs. 5–8. 5: The cross section of a ventral body hair showing the partition of medulla into two columns. (×4,120); *6:* Fore-limb hairs have elongated cuticular scales with conical shaped apices. (×1,280); *7:* The oval shaped roots of fore-limb hairs are shown. Note the development of cuticular scales on roots and the proximal openings of the medulla. (×2,390); *8:* The medullary cells of the fore-limb hair showing the pattern of arrangement of chamber-like formation with the development of intercellular septa. (×4,120)

Discussion

It has been emphasized that identification of ingested hair is a useful tool determining the feeding habits and food preferences of predators (Brunner and Coman 1974; Perrin and Campbell 1979). Identification of hairs may also play a salient role in the field of forensic science (Adorgan and Kolenosky 1969; Keogh 1983). However, only a few mammals have been subjected to systematic studies on the structure of hair (Noback 1951; Lyne and McMahon 1951; Benedict 1957; Stains 1958; Khemelevaskaya 1965; Day 1966; Adorjan and Kolenosky 1969; Trevor-Deutch 1970; Ryder 1973; Brunner and Coman 1974; Koppiker and Sabnis 1976, 1977; Perrin and Campbell 1979; Sokolov 1979; Keogh 1983; Rajaram and Menon 1986). Despite the structural differences of cuticular scales of different species of mammals discernible during these studies



Figs. 9–11. 9: Showing the hind-limb hairs with tightly packed flattened scales. (×1,540); *10:* A cross section of a hind-limb hair showing the pattern of arrangement of medullary cells. (×2,340); *11:* The tail hair with tightly packed, flattened cuticular scales. (×1,180)